Asymmetrical Half Bridge Double Input DC/DC Converter Adopting More Than One Renewable Energy Sources

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***Abstract*— This paper proposes an asymmetrical double input converter for low power applications. Double Input Converters (DICs) are special case of Multiple Input Converters where available MICs usually have complex configuration and numerous transformer windings. The proposed converters have advantages of simple architecture, soft-switching realization, and high conversion efficiency compared with available MICs. In this paper, the operating principle of DIC composed of two buck PVSC is analyzed. The open loop and closed loop simulation of the proposed converter is carried out and verified.**

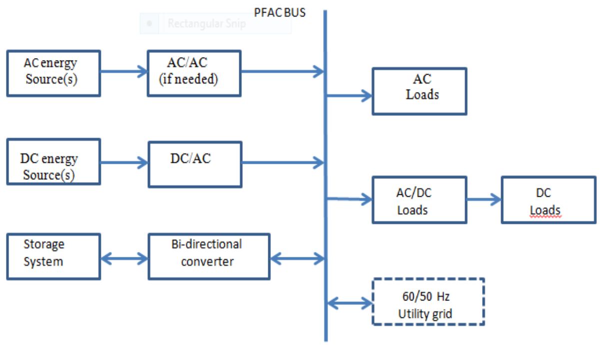
***Keywords*— Asymmetrical half bridge, double input, multiple input, pulsating voltage source cell.**

I. INTRODUCTION

In most power electronic systems, the instantaneous input and output power may vary by time and are not exactly identical with each other. Hence providing a good match between them is a complicated task to deal with if not possible. Furthermore, due to the wide variation range of the processed power, the overall efficiency of system is not high. The solution is to hybridize the system using an energy storage unit like in hybrid vehicles, power correction systems and photovoltaic systems.

The increased concern about the intensity of global energy shortage and environmental pollution caused by the use of fossil resources has led to renewed interest in renewable hybrid power system. Renewable hybrid power system differs from traditional power system in that the electricity they deliver can be generated from a wide range of sources, including PV energy, hydro energy, and wind energy, storage system, or any combination of these. Many of such sources are mutually complementary in the sense that they can be utilized simultaneously to maintain continuous delivery of power to the load. The conventional configuration of renewable hybrid power system consist so many numbers of independent single-input converters and a common voltage dc bus with a provision for multi voltage level distribution and intelligent energy and load management. Figure 1 shows the schematic diagram of a conventional AC coupled hybrid energy system.

Multi input converters play a key role in such hybridized systems, where it is required to have more than one power source. A multiple input converter is a circuit that accommodates input of more than one energy sources which are of the pulsating voltage source cells (PVSC),and provides at least one output. Such technologies can find application in residential, aerospace, automotive, portable electronics and any other application where there is the possibility of using more than one source. By diversifying the energy source, alternative energy can be better utilized and reliability can be increased.



A double input converters (DIC) is one special case of MIC where only two independent DC input sources are included. Such converter has lesser power components, simple configuration and soft switching realization. DICs should allow the input dc sources at each PVSC to power the load simultaneously or individually. For all basic single-input isolated dc/dc converters, it is possible to decompose each of them into a few basic stages, namely, a PVSC, a transformer, an output rectifier, and an output filter. The function of PSC is to provide an ac pulsating voltage or current and is capable of generating controllable power, which in turn can be stepped-up or stepped-down by the transformer and further rectified and filtered by the output stage to obtain a stable output voltage at the load. A typical PVSC consists of a dc voltage source and a switch network. The dc voltage source is connected to the terminal of PVSC through the switch network, and the power conversion process is properly controlled.

DICs should allow the input dc sources at each PVSC to have different nominal volt- age levels. Furthermore, it is also required that the input sources at each PVSC can power the load simultaneously or individually, which is defined as DSSM and SSSM, respectively. To generate an isolated voltage-fed DIC, the output of two PVSCs can be connected in series and applied to the primary winding of transformer directly, and then cascaded with rectifier and output filter, which is similar to the composition of single- input isolated converters.

I. CIRCUIT OPERATING PRINCIPLE

The objective of this paper is to analyse the working of a double input dc/dc converter and verify the result by using MATLAB/SIMULINK. The proposed dc/dc converter is shown in fig.2

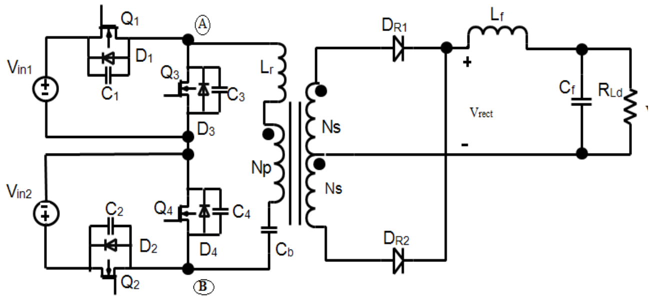


Fig. 2 Circuit Diagram

Vin1 and Vin2 are the magnitudes of two input power sources. Vin1, Q1 , and Q3 compose one buck PVSC, while Vin2, Q2, and Q4 compose the other buck PVSC. C1 to C4 are the junction capacitors of transistors Q1 to Q4, and combined anti parallel diodes D1 to D4 . Lr is the auxiliary resonant inductance to widen the load range for ZVS realization. Cb is the blocking capacitor to sustain the dc bias of the transformer.

The control strategy is adopted such that the phase shift between two outputs of PVSCs is set at π. The switching sequence of two switches in any PVSC is complementary. When the converter operates in double source supply mode, Q2 is lagging to Q1 by the half of a switching period, and the maximum duty cycle of Q1 and Q2 , i.e., Dy1 and Dy2 are limited at 0.5,

II. MODES OF OPERATION

The detailed operation principle under different operation modes is explained in the following. Before the analysis, the following assumptions are made:

1. the power devices, inductances and capacitors are ideal;
2. the output filter inductance is large enough to be regarded as a constant current source;
3. Cb is large enough to be regarded as a constant voltage source at the steady state, and Vcb =0.

The converter has 12 operation stages during a switching period in double source supply mode.

A. *Mode 1[prior to t0]*

Prior to t0, Q1 and Q4 conduct, source 1 provides power to load individually. Fig 3 shows the equivalent circuit of the mode1.

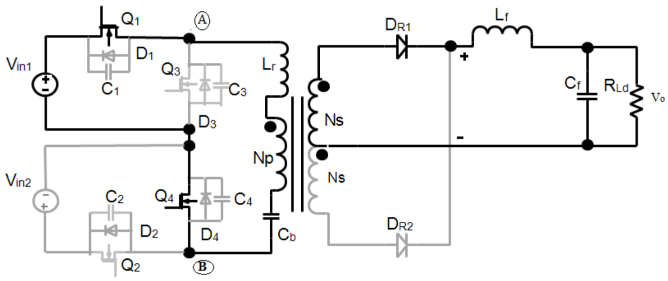


Fig. 3 Equivalent circuit of Mode 1 operation

B. *Mode 2 [t0.t1]*

At t0, Q1 is turned OFF, the primary current, ip charges C1 and discharge C3. As C1 and C3 limit the rising rate of the voltage of Q1, Q1 is zero-voltage turn-OFF. During this stage, the current source Io is reflected to the primary sides of the transformers and in series with the resonant inductance; therefore, the voltage of C1 (vc1) rises linearly, and the voltage of C3 (Vc3 decays linearly. At t1, vc3 rises to Vin1Vcb, and vc3 drops to VCb. Fig 4 shows the equivalent circuit of the mode 2

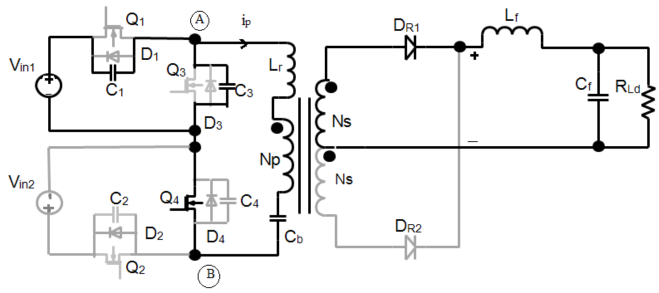


Fig. 4 Equivalent circuit of mode 2 operation

C. *Mode 3[t1,t2]*

When vC3 drops to VCb, the primary voltage of transformer tends to reverse the polarity, so DR2 conducts, which shorts the secondary windings and clamps the primary voltage at zero. Meanwhile, Lr resonates with C1 and C3 , and vC1 and vC3 vary in a resonant manner. Fig 5 shows the equivalent circuit of the mode 3.

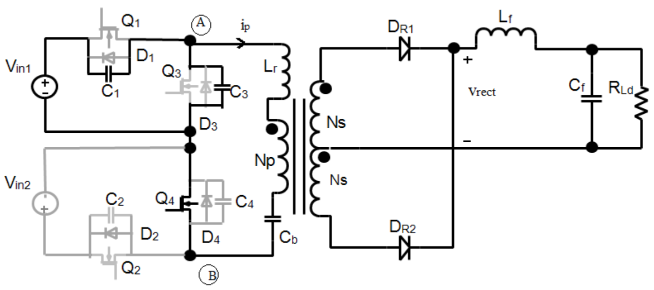


Fig.5 Equivalent circuit of mode 3

D. Mode 4[t2,t3]

At t2, vC3 drops to zero, D3 conducts naturally, therefore, Q3 is turned ON at zero voltage condition. Both the rectifier diodes conduct and share the output current, the primary and secondary voltage of transformer are both zero. VCb is applied on Lr ,and ip decays linearly. Fig 6 shows the equivalent circuit of the mode 4.

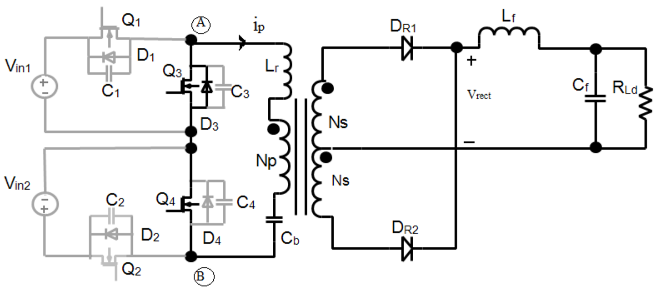
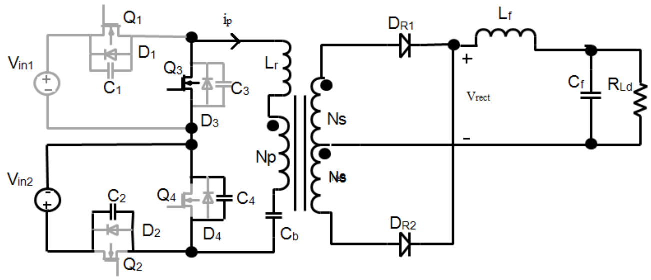


Fig. 6 Equivalent circuit of mode 4

E. Mode 5[t3,t5]

At t3, Q4 is turned OFF, ip charges C4 and discharges C2. As C2 and C4 limit the rising rate of the voltage of Q4,Q4 is zero-voltage turn-OFF. During this stage, the rectifier diodes still conduct simultaneously, which short the secondary windings, and Lr resonates with C2 and C4 . Fig 7 shows the equivalent circuit of the mode 5.



Mode 6[t5,t6]

At t4 , vC2 decays to zero, D2 conducts naturally, and Q2 is at zero-voltage turned ON. Vin2 and VCb are applied on Lr , and ip decreases rapidly and then increases in the reverse direction. Fig 8 shows the equivalent circuit of the mode 6.

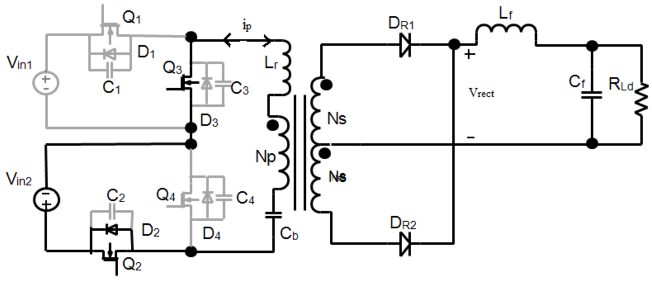


Fig. 8 Equivalent circuit of mode 6

F. Mode 7[t6,t7]

At t5, ip reaches the reflected load current, DR1 turns OFF, and the primary powers the load. Fig 9 shows the equivalent circuit of the stage 7.

At t6,Q2 is turned OFF, and the converter will operate in another half of switching period. The operation principle is similar to the analysis as described previously. The difference is that the voltages across Cb will influence the conduction of the rectifier diodes; therefore, the rectified voltage is not asymmetrical.

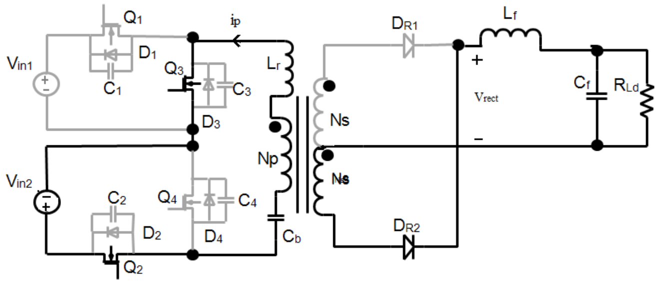
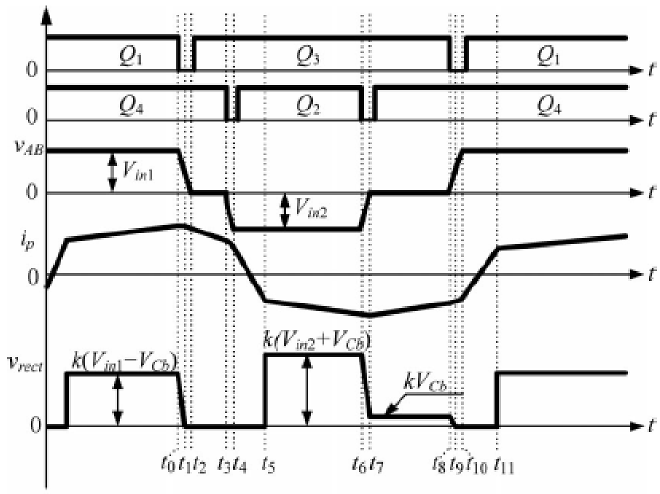


Fig. 9 Equivalent circuit of mode 7

III. WAVEFORM

Next section discussed about the waveforms in double source supply mode.



IV. SIMULATION

The specific intension of simulation analysis is to verify the switching signals as well as the output waveform.

The input voltages may vary during the operation of the converter. When the duty ratio is fixed, the output voltage will change in accordance with changes in input voltage. A feedback circuit is provided to correct the duty ratio in case of changes in input voltage to keep output voltage constant. The feedback circuit consists of an output voltage sensor, comparator and a controller. The controller output voltage is compared with a sawtooth wave generator operating at 100 kHz. The output of the comparator is the pulse width applied to the switches. Hence duty ratios are controlled to keep the output voltage constant. Simulation diagram is given in fig. 10 and the result of the simulation in fig. 11.

Simulation Parameters:

Input voltage Vin1= 200V, Vin2 = 290V
Output power P0=240W
Output voltage V0=48V
Duty cycle Dy1 = Dy2 = 0.1
Secondary to primary turns ratio k = 1.2
Switching frequency fs=100 kHz
Output current I0 = 5A

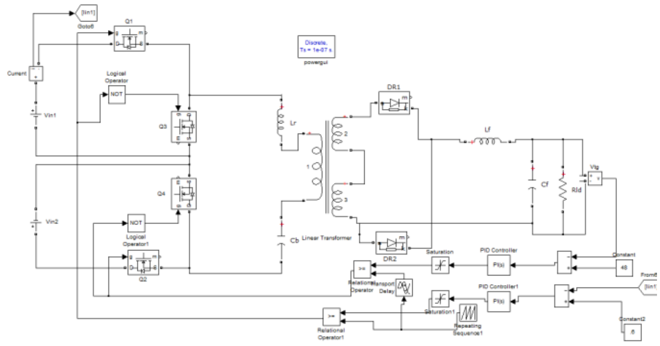


Fig. 10 Simulation diagram of closed loop system

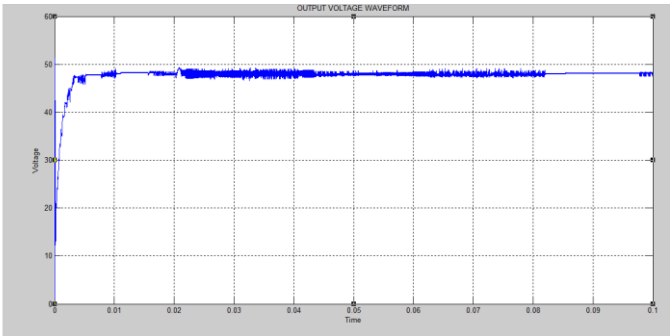


Fig. 11 Output waveform

V. CONCLUSION

In this paper, a method of generating the isolated DICs for low renewable power system was proposed and the operation principle and soft-switching characteristics of the DIC adopting two buck PVSCs are analysed in detail. The proposed DIC topologies in this paper have the advantages of simple configuration, less number of components, electrical isolation, and high conversion efficiency, which is very suitable for renewable hybrid power system.

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